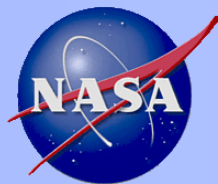


# JCL Journey: A Look into NASA's Joint Cost and Schedule Confidence Level Policy



Charles Hunt

In this Virtual Project Management Challenge, the presenter will provide an overview of JCL - covering the policy, explaining what JCL is, and providing the rationale for the policy. The presenter will also illuminate, utilizing concepts such as risk compensation and portfolio management, recent results of how a program's portfolio composition should influence JCL expectations of a project.



# Ask Questions, Find Help

**Virtual PM CHALLENGE**

## NASA Virtual Project Management Challenge

### Applications

- Twin Otter
- X-43A (Hyper-X)
- Sub-scale Transport Aircraft
- ARES I-X Launch Vehicle
- X-29A
- Tu-144LL Supersonic Transport
- 1903 Wright Flyer Replica
- Global Hawk

There are many others ...

16

### Tour the Player (Virtual PM Challenge)

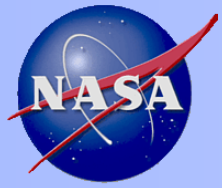
Info Chapters

Virtual PM Challenge

Send Technical Issues to:  
[nasa-virtual-pm-challenge@mail.nasa.gov](mailto:nasa-virtual-pm-challenge@mail.nasa.gov)

### Audience interaction

- Links** - link to related reference materials
- Share presentation** - email a presentation link bookmarked to play from a specific point
- Polls**
- Ask a question** ✓

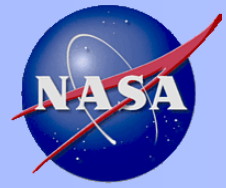


## JCL Journey: A Look into NASA's Joint Cost and Schedule Confidence Level Policy

# Introductory Remarks



Robert M. Lightfoot Jr.  
NASA Associate Administrator

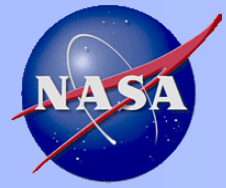


# **JCL Journey: A Look into NASA's Joint Cost and Schedule Confidence Level Policy**

**Virtual PM Challenge**

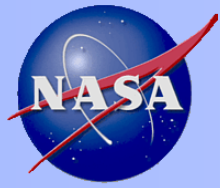
**August 15<sup>th</sup>, 2013**

**Charles Hunt**



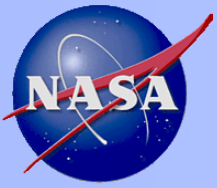
# Statement of Purpose

- **In this Virtual Project Management Challenge, the author will provide an overview of JCL**
  - Covering the policy
  - Explaining *what* JCL is
  - Providing the rationale for the policy
- **The author will also illuminate, utilizing concepts such as risk compensation and portfolio management, recent results of how a program's portfolio composition should influence JCL expectations of a project**
- **The author hopes this presentation will facilitate dialog between the general cost estimating and PM communities with regards to common cost estimating/management issues and possible solutions**



# Summary of NASA's Probabilistic Budgeting Policy

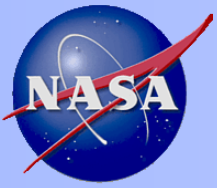
- **At KDP-B**
  - Projects must generate a low and high **cost and schedule** estimates with associated probabilities of completing at or below those costs/dates.
  - An independent SRB will evaluate project-generated results.
  - Decision authority will decide upon the low and high cost and schedule targets. Goal is to set budgets at a higher probability of success in order to give projects a better chance of success at KDP-C.
- **At KDP-C**
  - Projects must generate a cost-loaded schedule and **produce a JCL** that is executable within the available annual resources.
  - An independent SRB will evaluate the project-generated JCL results and model.
  - Decision Authority will decide the JCL (probability) for the associated development and life cycle cost at which the agency commits to deliver the project.



# KDP 1 / KDP C POLICY

## NPR 7120.5E

- Tightly coupled and single-project programs (regardless of life-cycle cost) and projects **with an estimated life-cycle cost greater than \$250 million** shall develop probabilistic analyses of cost and schedule estimates to obtain a quantitative measure of the likelihood that the estimate will be met in accordance with the following requirements.
- At KDP I/KDP C, tightly coupled and single-project programs (regardless of life-cycle cost) and projects with an estimated life-cycle cost greater than \$250 million shall develop a **resource-loaded schedule and perform a risk-informed probabilistic analysis that produces a JCL**. The JCL is the product of a probabilistic analysis of the coupled cost and schedule to measure the likelihood of completing all remaining work at or below the budgeted levels and on or before the planned completion of Phase D.
- Mission Directorates shall **plan and budget** tightly coupled and single-project programs (regardless of life-cycle cost) and projects with an estimated life-cycle cost greater than \$250 million **based on a 70 percent joint cost and schedule confidence level, or as approved by the Decision Authority**.

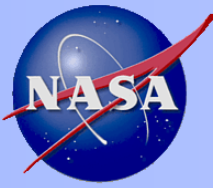


# KDP 1 / KDP C POLICY

## NPR 7120.5E

- Any JCL approved by the Decision Authority at less than 70 percent shall be justified and documented.
- Mission Directorates shall ensure **funding** for these projects is consistent with the Management Agreement and in no case less than the **equivalent of a 50 percent JCL**.
- When a tightly coupled program, single-project program, or project with an estimated life-cycle cost greater than \$250M is **rebaselined, the JCL should be recalculated** and approved as a part of the rebaselining approval process.
- Loosely coupled and uncoupled programs are not required to develop program cost and schedule confidence levels. These programs shall provide analysis that provides a status of the program's risk posture that is presented to the governing PMC as each new project reaches KDP B and C or when a project's ABC is rebaselined.

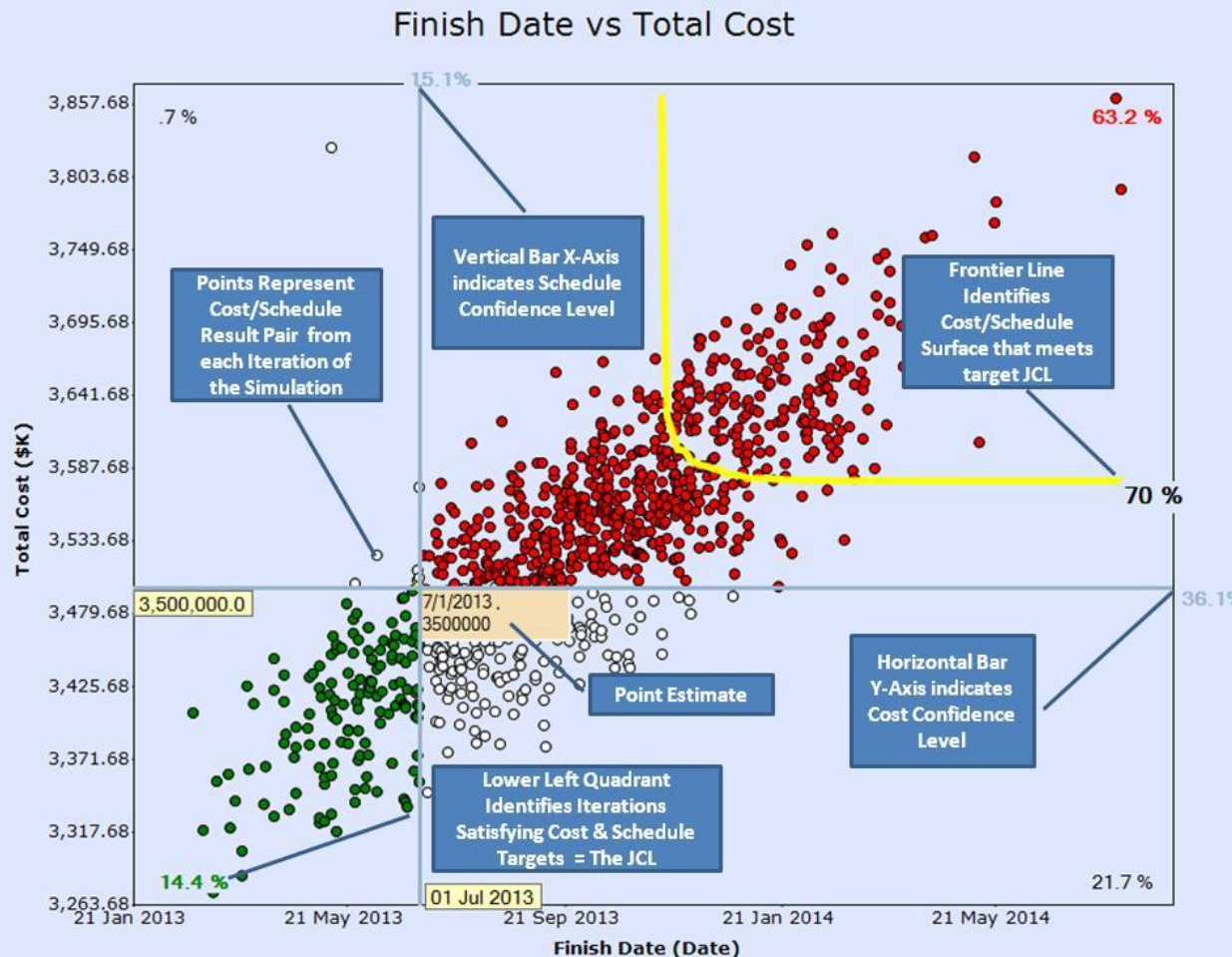




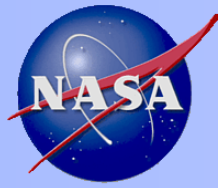
# What is a JCL?

## JCL = Joint Cost and Schedule Confidence Level

Identifies the probability that a given project or program's cost will be equal or less then the targeted cost AND the schedule will be equal or less then the targeted schedule date.



- Each dot in the scatter plot represents a result from the simulation calculation (Cost, Schedule).
- Scatter plot shows iterations of cost and schedule risk analysis.
  - Cross-hairs can be moved to a date and cost to obtain their joint confidence.
- Analysis results valid only for plan the inputs are based on, and represents a snapshot in time.



# Standard Steps in Performing a JCL Analysis

## 1. Build a JCL schedule/logic network

- Logic network
- Minimize use of constraints
- Link to major milestones
- Schedule Health Check for viability for analysis

## 2. Cost Load the Schedule

- Map cost to schedule
- Load as resources if using schedule system
- Determine phased fixed/variable costs and assign to schedule/logic network

## 3. Implement Risk List

- Quantify likelihood and cost/schedule impacts
- Link to schedule/network activities
- Load risks

## 4. Conduct Uncertainty Analysis/Populate 5x5s

- Schedule Uncertainty
- Cost Uncertainty

## 5. View Results & Plot

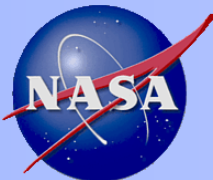
## 6. Analyze results and refine (steps 1-5)

**Step Zero: CAD works with Program/project to Identify goals for JCL**

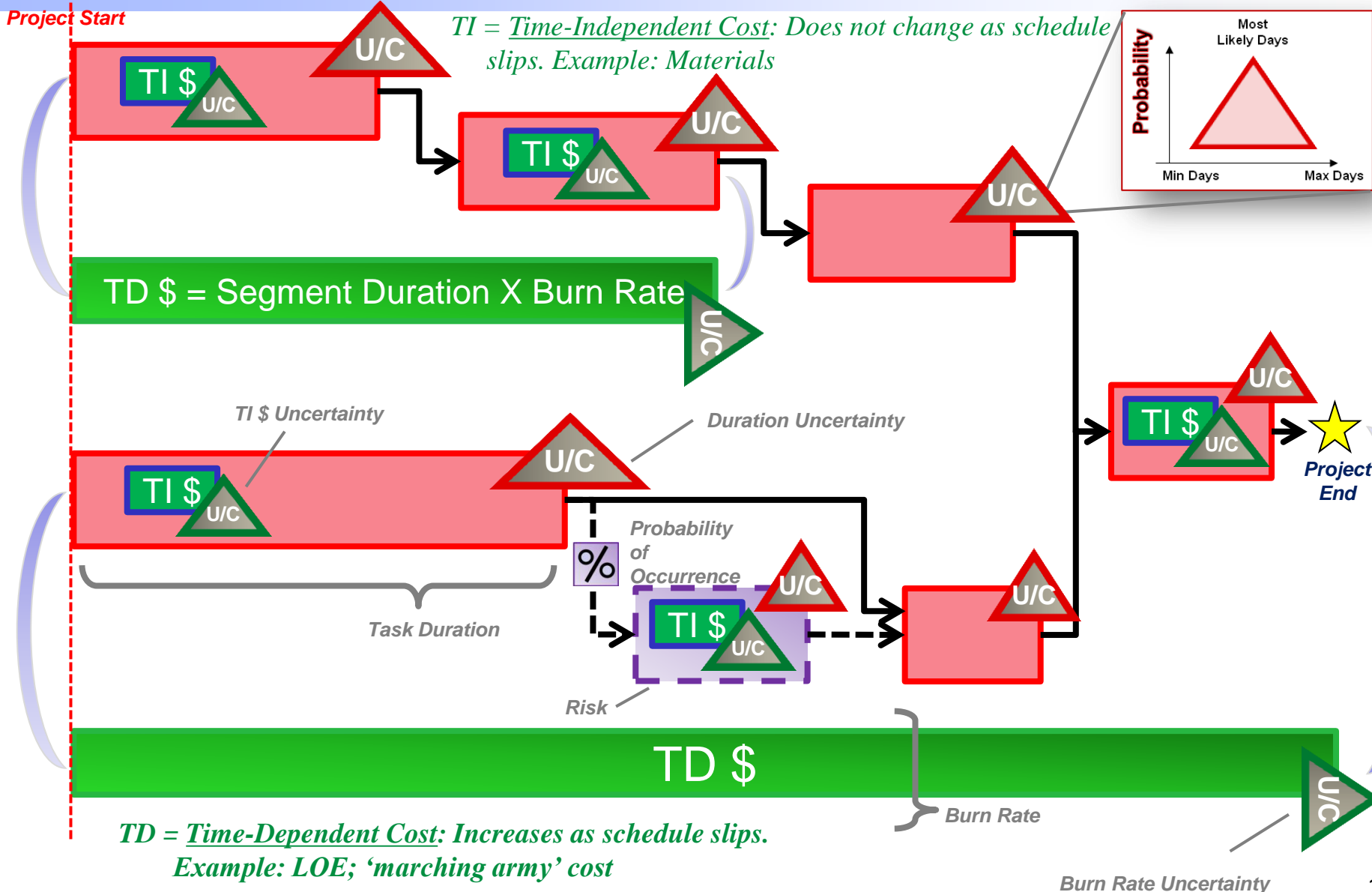
**What questions to answer?**

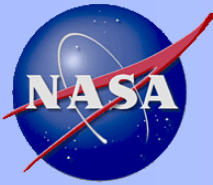
**Who to use?**

**What insight to gather?**



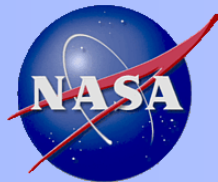
# JCL: Data Integration Mechanics





# JCL Lessons Learned - Benefits

- **Improves project planning by integrating cost, schedule, and risk products and processes.**
- **Focuses on the inputs to project plans instead of the outputs.**
  - NASA management resonates with the discussion of specific technical and programmatic inputs.
  - Facilitates better communication between the project and the independent review team.
- **Complements many of the Agency's existing systems and activities (e.g., Risk Management Systems, Earned Value Management).**
- **Reserve levels for schedule and cost are not dictated by standards or rules of thumb, but derived from the project's unique technical and programmatic characteristics (cost reserves treated as unallocated future expenses).**
  - Facilitates better understanding and communication of project health to external stakeholders.
- **Incorporates schedule into the confidence level calculation.**
  - Genesis of Joint Cost and Schedule Confidence Level (JCL).
  - Forces project to address and understand time independent and time dependent costs.
  - Enforces scheduling best practices (i.e., schedule health checks).
- **Strengthens risk management.**
  - Quantifies risks in terms of cost and schedule impacts.
  - Addresses risk realization instead of only risk mitigation.
- **Policy has flexibility to accommodate confidence levels that differ from the 70/50 baseline, if justified and documented by the Decision Authority.**



# Decision Support and Policy

- **Form follows function: Need to fully understand root causes for growth and develop policies to address them.**

Cost Growth Reasons	1970s	1980s	1990s	2000s
Inadequate definitions prior to agency budget decision and to external commitments	X	X	X	X
Optimistic Cost Estimates/Estimating Errors	X	X	X	X
Inability to execute initial schedule baseline	X	X	X	X
Inadequate risk assessments	X	X	X	X
Higher technical complexity of projects than anticipated	X	X	X	X
Changes in Scope (Design/Content)	X	X	X	X
Inadequate assessment of impacts of schedule changes on cost		X	X	X
Annual Funding instability			X	X
Eroding in-house technical expertise			X	X
Poor tracking of contractor requirements against plans			X	X
Launch Vehicle			X	
Reserve Position adequacy		X		X
Lack of Probabilistic estimating		X		X
"Go as you can afford" Approach				X
Lack of formal document for recording key technical, schedule and programmatic assumptions (CARD)**				X

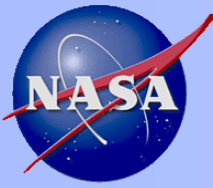
\*\* CADRe has since been implemented as a requirement of NPR 7120.5

If we want projects to meet cost and schedule commitments, we must understand their risks and fund them at a level commensurate with the amount of risk we are willing to accept.



# Why Do Cost Estimates in the First Place?

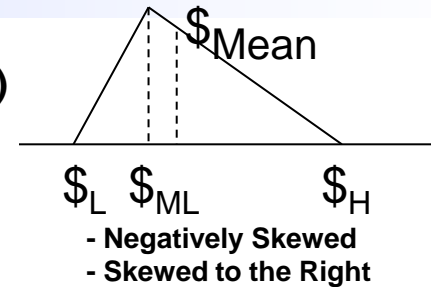
- **Why don't we take the Project Manager's point estimate?**
- **Is the "point" estimate equal to ...**
  - ... the "most Likely" or "most probable" cost?
  - ... the 50th-percentile cost?
  - ... the expected cost?
- **No – It is not likely to be equal to any of these**
- **There is, in fact, a range of possible cost values**
  - The "point" estimate is not the only possible estimate
  - If the "point" estimate is the "most likely" cost, then other cost levels can be assumed to be "less likely"
  - If the "point" estimate is the "50<sup>th</sup> percentile" cost, then there are cost levels corresponding to 99 other percentiles
  - If the "point" estimate is the "expected" cost, then other cost levels are presumably "unexpected"
- **Project managers need "Point Estimates" for ...**
  - ... Cost/performance tradeoff studies
  - ... Cost/benefit analyses
  - ... Budget Planning
- **But a project "point" estimate is often nebulous due to ...**
  - ... Immature technology – TRL assumed higher than it is
  - ... Uncertain product design
  - ... Software-associated issues
  - ... Requirements volatility
  - ... Programmatic and organizational considerations
  - ... Schedule slips due to integration difficulties and test failures
  - ... Unforeseen events
- **While "point" estimates are not "correct", "actual" Project cost will typically fall within some range (with some degree of confidence)**
  - The best we can hope to do is to understand the amount of uncertainty
  - Understanding the uncertainty will help us make provision for it



# Why Not Just Go With the Point Estimate?

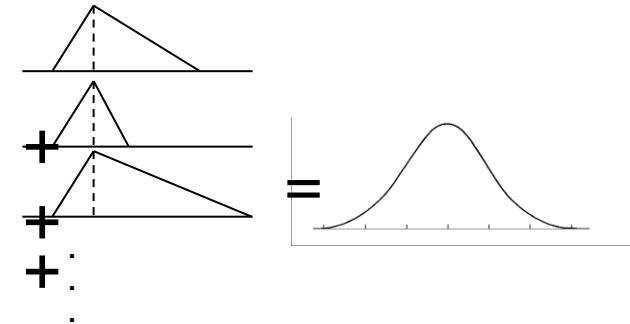
More Things can go Wrong than Right

- Murphy's Law (4<sup>th</sup> Law of Thermal Dynamics)
- Inherently Optimistic (Bias)
- Moral Hazard
- \$\$\$\$ happens



Central Limit Theorem

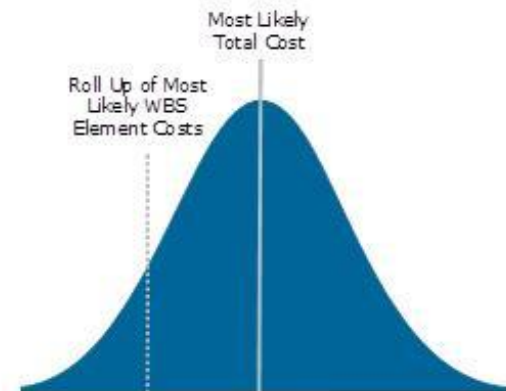
States conditions under which the mean of a sufficiently large number of independent random variables, each with finite mean and variance, will be approximately normally distributed

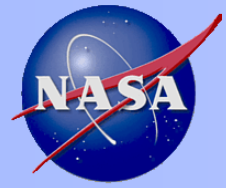


Sum of the Means Equals the Mean of the Sums

Mean Sum Theorem

The total mean = the sum of the WBS element means  
The total median = the sum of the WBS element means  
The total mode = the sum of the WBS element means  
The sum of the WBS element modes < total cost mode  
The sum of the WBS element medians < total cost median



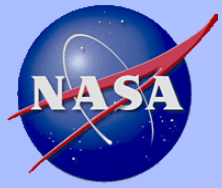


# What Should We Do?

- **Treat every cost-estimating task as a cost-risk analysis**
  - Recognize uncertainty inherent in every estimate
  - Construct a probability distribution of cost for each cost element
- **Sum cost-element costs statistically or analytically**
  - Get mean, median, mode of system cost
  - Get all cost percentiles
  - Assign degree of confidence to anybody's estimate

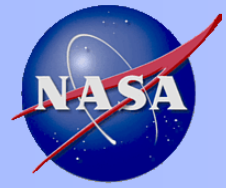
**A TECHNICAL REALITY:** Fundamental inability to predict the future!  
Since it is impossible to make exact predictions we have account for risk and uncertainties in cost AND schedule assessments





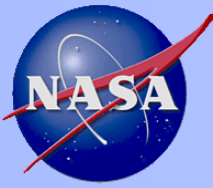
# So, Where Should We Set the Budget?

- *There is no “best” answer*
- The “answer” depends on the amount of budget available or requested, and the amount of risk the decision-maker is willing to take
- A risk-averse decision-maker would probably choose a budget reflecting a cost with a high probability of realization
  - To minimize the probability of a cost overrun
- A risk-tolerant decision-maker might budget at a lower number, challenging a program manager to greater risk management
- Budget decisions should consider the risk across the entire portfolio of programs
  - Portfolio analysis was key attribute to determining NASA probabilistic policy



# Portfolio Analysis Review

- **Modern portfolio theory (MPT) is a theory of finance which attempts to maximize portfolio expected return for a given amount of portfolio risk, or equivalently minimize risk for a given level of expected return, by carefully choosing the proportions of various assets**
- **MPT is a mathematical formulation of the concept of diversification in investing, with the aim of selecting a collection of investment assets that has collectively lower risk than any individual asset**
- **The “portfolio effect” is defined as the tendency for the risk on a well-diversified holding of investments to fall below the risk of most and sometimes all of its individual components**

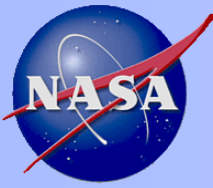


# Portfolio Analysis

## Mission Portfolio

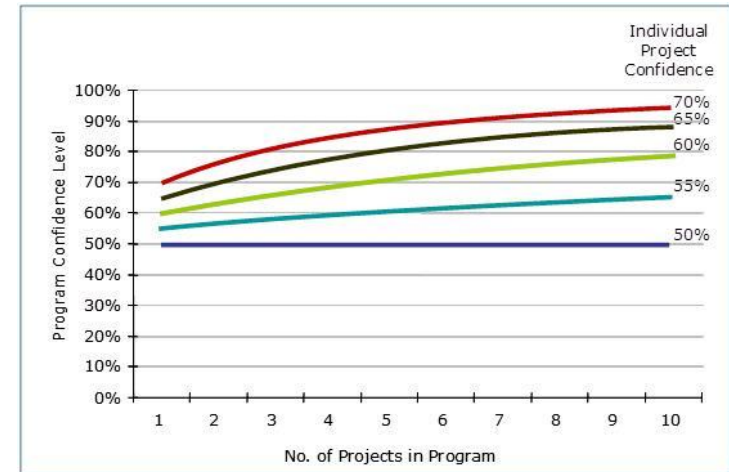
- Using the portfolio principles, individual project confidence levels can roll up to higher or lower confidence levels at the program level
- Applied to an Agency's mission portfolio, the portfolio effect can be applied to understanding the relationship between confidence at the Agency's (or Program's) level and confidence at individual project level
- For the portfolio effect to work, projects within a program (within a portfolio) that turn out not to require their entire original budget must be managed in such a way that their unused budget is available to other projects
- These unneeded resources are then available to be used for projects which exceeded their budgets.

Decision makers can fund projects at lower confidence levels while achieving higher confidence levels from an Agency or Program viewpoint (Anderson, 2004)

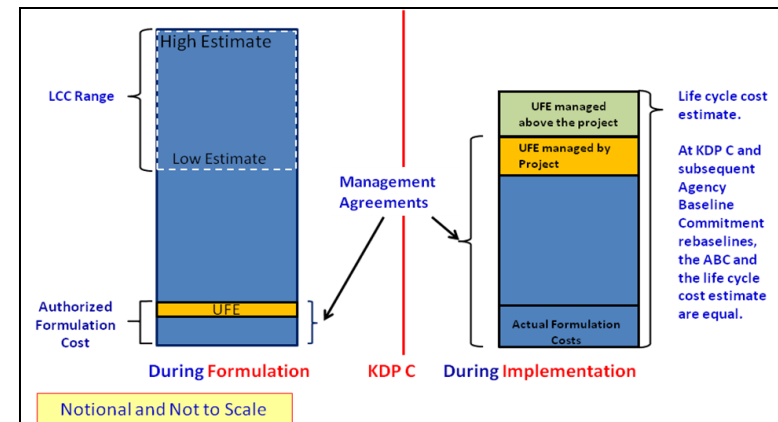


# Portfolio Analysis NASA Implementation

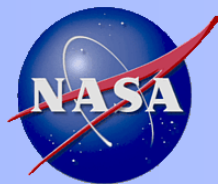
- **The portfolio effect was one of the primary drivers to NASA's original probabilistic cost policy implementation (Hamaker, 2006)**
  - Original policy was cost confidence only and did not address schedule confidence
  - Assumed max portfolio effect
- **With the implementation of Joint Cost and Schedule Confidence Level, consideration and dialog of portfolio analysis was not a driving factor in policy CLs (70<sup>th</sup> and 50<sup>th</sup> percentiles), (Coonce, 2009)**
  - Driving factor was including schedule
  - 70<sup>th</sup> percentile was adopted from previous policy
  - 50<sup>th</sup> percentile was adopted to give the projects a 50/50 chance
  - NASA set up a tiered system to help account and incentivize portfolio behavior



[Adapted from Book]  
Assumes normal distributions)



**NASA Policy can enable portfolio behavior**



# Evolution of Confidence Level Analysis at NASA

## Project Estimates (Advocacy)

### Project

Primarily Bottoms up  
Point Estimates and  
Cost Confidence Levels

Joint Cost and Schedule  
Confidence Level (JCL)

2002 and  
before

2003 - 2007

2/2007

1/2009

5/2009

12/2009

11/2010

8/2012

### Assessment

Parametric  
estimates and  
Assessment

*Formalized Cost  
Confidence Level  
Policy (2006)*

*JCL Policy  
Established*

*Cost-Loaded  
Schedule  
Requirement  
Established*

*Refined  
Requirements  
for KDP-C  
Established*

*Add KDP-B  
Confidence  
Levels  
for cost &  
schedule  
ranges*

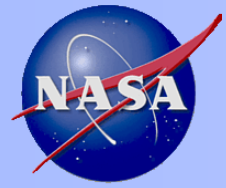
*NPR  
7120.5E  
Effective*

Parametric-Based  
Confidence Levels

Assessment of Project JCLs

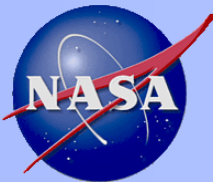
KDP-B cost &  
schedule  
probabilistic  
ranges

## “Independent” Estimates (Non-Advocacy)



# Recent Investigation

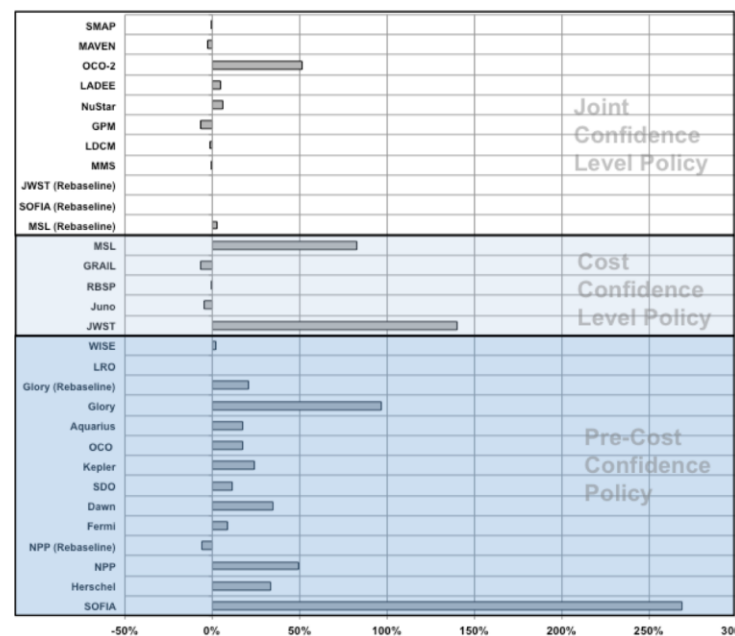
- **CAD sponsored research to Aerospace Corp. in FY12 to investigate ramifications of JCL policy with regards to different types of portfolios**
  - Project confidence levels would be varied parametrically to determine portfolio characteristics at various confidence level strategies
  - Study took in account Risk Compensation
    - Or moral hazard, which is the tendency for people to adjust their behavior in response to perceived level of risk
    - If funded at higher confidence levels, projects will tend to spend all available funds
- **Conclusions:**
  - Analysis shows that for a typical portfolio of multiple loosely coupled missions, NASA's baseline JCL policy of budgeting projects at the 70<sup>th</sup> percentile and funding to at least the 50<sup>th</sup> is a sound strategy
  - However, for single-project Programs, due to risk compensation and lack of portfolio, deviations may be warranted
  - Several additional risk posture strategies could be implemented depending on management figures of merit (FOM), priorities, and Program characteristics



# JCL Conclusion

- **JCL improves project planning by systematically integrating cost, schedule, and risk products and processes while providing a cohesive and holistic picture of the project ability to achieve cost and schedule goals and to help the determination of reserves (schedule and cost)**
  - Empirical Evidence: Since probabilistic policies have been put in place, programmatic performance has improved.
  - Theoretical Evidence: Recent analysis shows that for a typical portfolio of multiple loosely coupled missions, NASA's baseline JCL policy of budgeting projects at the 70th percentile and funding to at least the 50th is a sound strategy
- **The focus early on was on the process**
  - New method, new analysis, new process.
  - Time spent educating/instructing
- **Process and method have been tailored over time**
  - Organizations are gaining experience running the processes
- **Quality of the inputs is now the focus**
  - Process provides a good framework, needs to be populated with realistic and appropriate inputs.

*“Over the past several years, NASA has made positive changes that have helped contribute to the improved performance of its projects. For example, NASA instituted the joint cost and schedule confidence level (JCL) process... This information should allow the Congress sufficient information to conduct oversight and ensure earlier accountability and should bring more attention to and focus on conducting early, reliable estimates of project costs.”* Source: GAO-13-276SP Assessments of Selected Large-Scale Projects, April 2013, p. 22

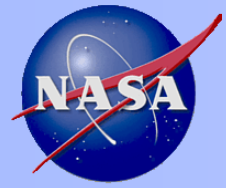




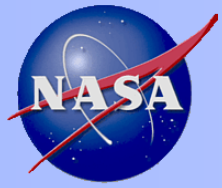
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- GAO-13-276SP Assessments of Selected Large-Scale Projects, April 2013, p. 22
- NASA, ADDRESSING MANAGEMENT CHALLENGES AND IMPROVING PERFORMANCE , [http://www.nasa.gov/pdf/754125main\\_12-NASA\\_FY14\\_M%26P508-pt3.pdf](http://www.nasa.gov/pdf/754125main_12-NASA_FY14_M%26P508-pt3.pdf)





**QUESTIONS?**



# UPCOMING WEBCAST

**Title:           Program Managers' Lessons Learned**  
**Date:           September 2013**

Check PM Challenge website for latest information